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Degradability Characteristics of Treated and Untreated Barley Grain Using *In situ* Technique

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Abstract: This study was carried out to determine of degradability characteristics of untreated barely grain (UBG) and treated barley grain with autoclaving at 120°C, 5´ (TBG_1) and 20' (TBG_2), treated barley grain at 100°C, 5´ (TBG_3) and 20' (TBG_4), using *in situ* technique in Ghizel sheep's. The sheep fed diet content 40% alfalfa: 60% concentrate containing 2.9 Mcal kg^{-1} DM and 14% CP. The incubation times were 0, 4, 8, 16, 24, 36 and 48 h and rumen degradation of cp and DM was measured. The equation of $p = a+b (1-e^{-ct})$ was used for fitting of dry matter and crude protein disappearance data. The dry matter disappearance of TBG_1 and TBG_2 at 24 and 48 h were lower than the other treatments ($p<0.05$). The crude protein disappearance of 24 and 48 h of UBG was more than the other treatment ($p<0.05$). Treating of barley grain of 120°C (5' and 20') can be decreased ruminal crude protein degradability of barley grain resulting high escaped crude protein into lower digestive tract.

Key words: Dry matter, crude protein, heat treating, *in situ*

INTRODUCTION

In ruminants protein requirements express as Ruminal Degradable Protein (RDP) and Undegradable Dietary Protein (UDP). Ruminal degradability depends on protozoa and bacteria activities, site of bacteria attachment. Barley grain is one of the most common feed grains used in diets for ruminant livestock species. Protein from barley grain constitutes a significant part of the dietary protein. However, the protein in barley and oats is extensively degraded in the rumen, resulting in a rather low protein value. Nylon bag studies have shown that expander treatment can protect protein in barley or oats against ruminal degradation[11,18,27] and thereby increasing their protein value by shifting the site of protein digestion from the rumen to the small intestine.

The positive correlation reported between Rumen Degradation of Starch (RDS) and protein in a study with pressure toasting of legumes[6]. Ljokjel *et al*.[9,10] reported that heat treatment decrease ruminal degradation of starch in both barley grain and pea grain. Barley grain treated by the steam flak, flame rusting and exploring can be decreased ruminal crude protein[13]. Fiems *et al*.[4] showed that processing of barley grain using steam flak decreased ruminal crude protein degradability.

McNiven *et al*.[13] found that flame roasting of barley grain decreased rate and extent of ruminal dry matter and crude protein disappearance but didn't influence intestinal digestibility of nutrients. Robinson and McNiven[19] found low rate dry matter degradability for roasted barley grain compared to untreated barley grain (0.262 vs. 0.534 h^{-1}), but didn't affect on extent degradability. The objective of this study was to determine of degradability characteristics of dry matter and crude protein of untreated and heat treated of barley grain using *in situ* method.

The objectives of this experiment were to study effects of heat treatment (autoclaving) and treatment time on *in situ* rumen degradability of protein in barley in sheep.

MATERIALS AND METHODS

The experimental feedstuff was barley grain. The feedstuff samples were ground on hammer mill through a 1 mm screen and a sample was taken as untreated Barley grain. After milled other samples heated using autoclave and treatment named Untreated Barley Grain (UBG), treated barley grain at 120°C, (5') (TBG_1) and 20' (TBG_2), treated barley grain at 100°C (5') (TBG_3) and 20' (TBG_4). In all samples, nitrogen (Kjeldahl-N) and dry matter were determined as described by AOAC[1]. Acid-detergent fiber and (NDF) were determined according to Van Soest *et al*.[23]. Ruminal degradation measurements were carried out using nylon bag methods mainly as described by Madsen *et al*.[12]

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and Prestlǿkken[18]. Three fistulated Gizel sheep (37+3.5 kg) were used. The sheep fed diet content 40% alfalfa: 60% concentrate containing 2.9 Mcal kg^{-1} DM and 14% CP. The nylon bags containing 5 g of samples were incubated into rumen at, 0, 2, 4, 8, 16, 24 and 48 h. The crude protein and dry matter disappearance do to were fitted with equation of $p = a+b (1-e^{-ct})$ that p was the degradability at time t, a soluble fraction, b insoluble fraction, c rate of degradation and t was time incubation. The dry matter and crude protein disappearance data were analyzed using statistical Analysis System[21].

RESULTS AND DISCUSSION

The chemical composition of barley grain is shown in the Table 1. The CP and NDF in UBG were more than reported the NRC[16], but ADF in UBG was lower than the NRC reports. This difference can be expected due to differences in environmental factors, type and variety of barley grain. The dry matter disappearances are shown in Table 2 and 4. The dry matter disappearance of treated barley grain at 48 h for TBG and TBG2 was lower than the other treatments ($p<0.05$), which s consistent to observations of Engstrom *et al.*[3] found that steam rolling reduced in sacco DM disappearance at 0, 8 and 24 h of incubation and reduced starch disappearance by 21.2% at 0 h and 12.8% at 8 h of incubation, compared to dry rolled barley. Similarly, Fiems *et al.*[4] observed that steam processing reduced the in sacco CP degradation rate of barley and wheat. The dry matter disappearance data obtained in this experiment was different from the reports of other studies[20,22]. These differences can be resulted from variation in type, variety and processing.

The crude protein disappearance data are shown in Tables 3 and 5. The CP disappearance data in heat treated barley grains were lower that the UBG ($p<0.05$).

Table 1: Chemical composition of barley grain (%)

Feed	DM	CP	ADF	NDF
Barley grain used in this experiment	92	11.56	6.0	26.8
Barley grain in NRC (1985)	90	10.80	6.6	20.1

Table 2: Rumen dry matter (DM) degradation characteristics for barley grains

Parameters					
RSD	ED[a]	c	b	a	Feedstuff
3.0	64.0	0.10	53.81	19.5	UBG
2.0	58.5	0.08	51.00	17.0	TBG 1
3.0	55.7	0.08	47.90	17.0	TBG 2
1.0	62.0	0.14	49.90	18.0	TBG3
1.5	65.0	0.15	51.90	19.0	TBG4

[a]: Degradation at a rumen particulate outflow rate of 2% h^{-1}

This finding was consistent with the reports of Ljokjel *et al.*[10], fiems *et al.*[4], McNiven *et al.*[13] and prestløkken[18]. Ljøkjel *et al.*[10] showed the treating of barley grain at 100°C and 150°C decreased CP degradability. When heat is added, bonds that stabilise the three-dimensional structure of proteins will break. If hydrophobic groups are exposed, this will result in reduced solubility of proteins[24] and consequently reduced ruminal degradation of protein. McNiven *et al.*[13] and Prestlǿkken[18] have discussed mechanisms for the different response of barley and oats to heat treatments. Differences in morphologic configuration of the starch-protein matrix probably play an important role.

The soluble and insoluble of CP in UBG was numerically more than the other treatment (Table 3). Also the effective degradability of CP (ED) at treated barley grain at 120°C was numerically lower than the other treatments (Table 3). The differences of CP

Table 3: Rumen Crude Protein (CP) degradation characteristics for barley grains[†]

Parameters					
RSD	ED	c	b	a	Feedstuff
2	48.5	0.03	65	9.2	UBG
1	32.6	0.03	43	4.9	TBG 1
3	43.9	0.02	95	4.2	TBG 2
2	37.5	0.04	52	2.4	TBG3
4	45	0.03	73	2.5	TBG4

[†]: Degradation at a rumen particulate outflow rate of 2% h^{-1}

Table 4: Rumen dry matter (DM) degradation of treatments in different incubation times (%)

Incubation time						
48	24	16	8	4	0	Feedstuff
73.95^{a}	65.23^{ab}	63.68^{a}	44.32^{bcd}	40.72^{ab}	18.145^{a}	UBG
65.49^{bc}	64.48^{ab}	55.94^{b}	40.57^{cde}	30.98^{b}	18.12^{a}	TBG 1
63.33^{bc}	58.21^{b}	56.1^{b}	35.3^{de}	32.15^{b}	17.49^{a}	TBG 2
67.94^{ab}	66.06^{a}	64.95^{a}	51.06^{ab}	40.44^{ab}	18.36^{a}	TBG3
72.37^{a}	69.16^{a}	64.83^{a}	55.1^{a}	44.40^{a}	18.78^{a}	TBG4
1.3	1.8	1.6	1.5	1.3	1.1	SEM

SEM = Standard error of the mean. [a, b, c]: Each column means with a different superscript are significantly different ($p<0.05$)

Table 5: Rumen Crude Protein (CP) degradation of treatments in different incubation times (%)

Incubation time						
48	24	16	8	4	0	Feedstuff
59.59^{abc}	42.39^{a}	32.42^{a}	24.37^{a}	19.70^{a}	6.84^{a}	UBG
40.94^{d}	27.89^{cb}	23.42^{abc}	18.06^{ab}	10.27^{bc}	4.03^{abc}	TBG 1
51.64^{abc}	35.09^{ab}	18.79^{abc}	14.39^{b}	9.26^{bc}	5.95^{ab}	TBG 2
46.53^{bcd}	37.45^{ab}	26.06^{abc}	18.21^{ab}	7.07^{cd}	4.36^{abc}	TBG3
55.56^{abc}	39.75^{ab}	31.79^{ab}	12.85^{b}	7.06^{cd}	6.33^{ab}	TBG4
2.5	2.08	1.90	1.10	1.00	0.40	SEM

SEM = Standard error of the mean. [a, b, c]: Each column means with a different superscript are significantly different ($p<0.05$)

degradation characteristics between treatments can be resulted of effect of heat processing on quantity and quality of protein (prolamin, glutelin), physiochemical structure of protein.

McGregor *et al.*[15] reported that processing of barley grain did not affect productivity of dairy cows and dry matter intake, milk yield, milk energy output milk fat concentration was not affected by steam-rolled barley grain.

In the present study, low degradable protein of heated barley grain perhaps supporting the view that heat treatment affects the formation of protein matrix more resistant to proteolysis[6] And indicating that the chemical reactions involved, such as Maillard reactions and formation of disulphide bridges, occur at heat treatment, in agreement with previous reports[5,7,24]. Other reactions that may proceed at Heat treated grain, involved such as isopeptide crosslinks, amino acids, lysine and serine[5], asparagine and glutamine[8] and methionine and tryptophan[2].

The obtained data for CP degradability parameters were differed from the reported of other studies[4,9,10,20,22]. These differences were probably due to variation in environmental factors, type and processing.

CONCLUSION

Heat processing of barley grain decreased CP degradability resulting, increased escaped CP into lower digestion tract. This finding confirmed the hypothesis of Prestløkken[14] who showed low degradability of barley grain due to of heat treating. Effects of processing barley grain have been extensively evaluated for cattle, but little is known for the effects on productivity of sheep's and this warrants further investigation.

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